FIG.1

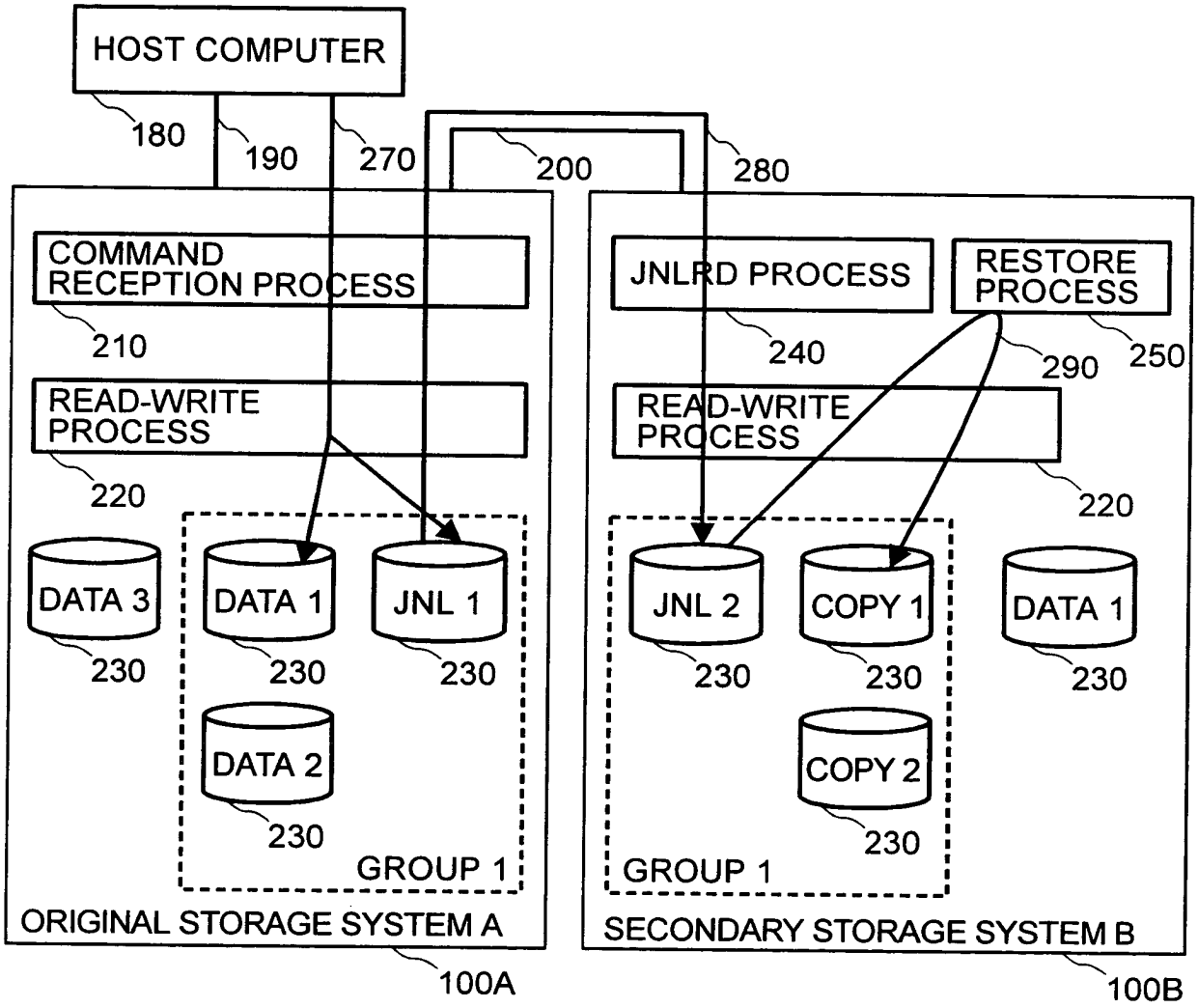
HOST COMPUTER
180
190
270
200
280
COMMAND RECEPTION PROCESS
210
READ-WRITE PROCESS
220
DATA 3
230
DATA 1
230
JNL 1
230
DATA 2
230
GROUP 1
ORIGINAL STORAGE SYSTEM A
100A
JNLRD PROCESS
240
RESTORE PROCESS
250
290
READ-WRITE PROCESS
220
JNL 2
230
COPY 1
230
DATA 1
230
COPY 2
230
GROUP 1
SECONDARY STORAGE SYSTEM B
100B

FIG.2

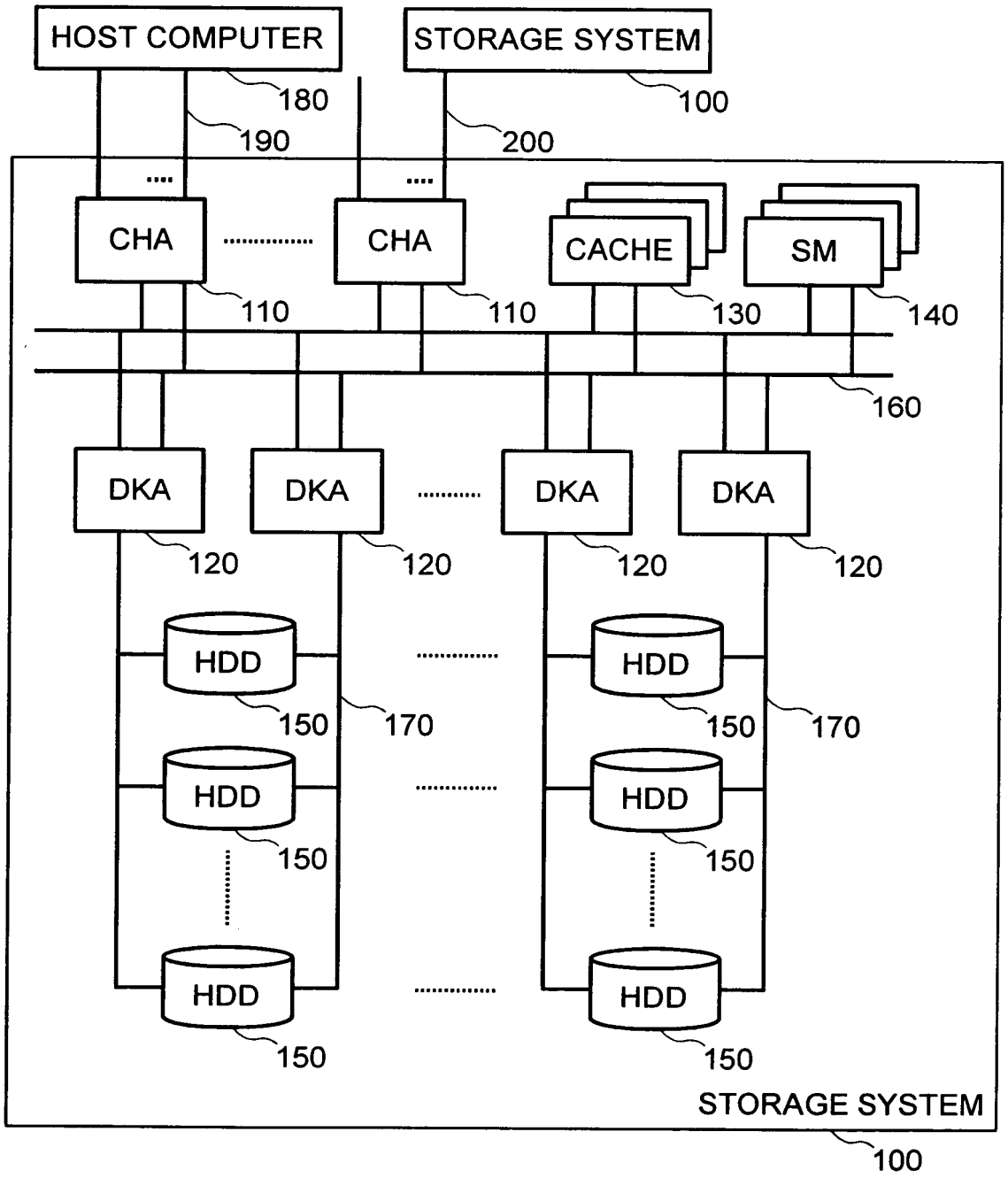
HOST COMPUTER
STORAGE SYSTEM
180
100
190
200
CHA
CHA
CACHE
SM
110
110
130
140
160
DKA
DKA
DKA
DKA
120
120
120
120
HDD
HDD
150
170
150
170
HDD
HDD
150
150
HDD
HDD
150
150
STORAGE SYSTEM
100

FIG.3

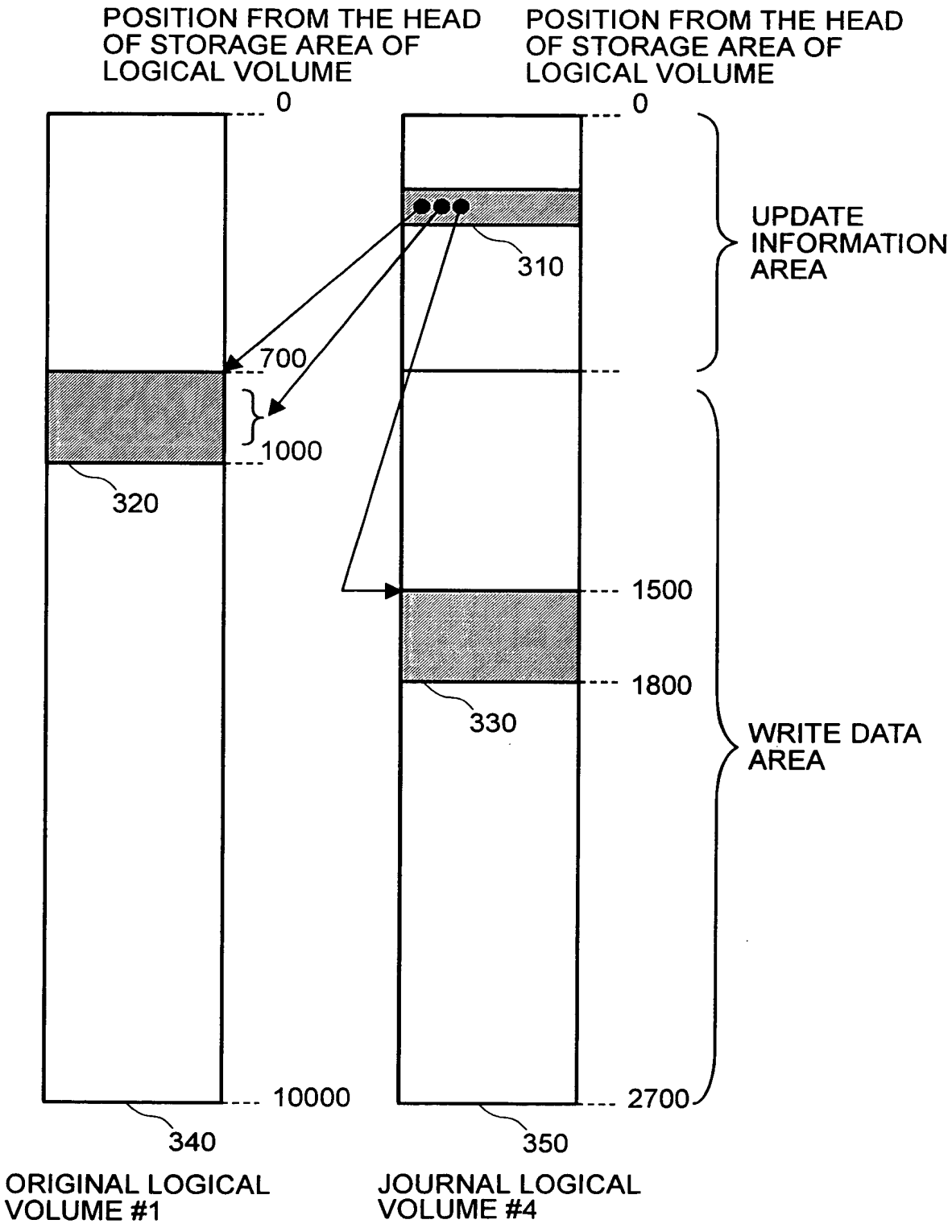
POSITION FROM THE HEAD OF STORAGE AREA OF LOGICAL VOLUME
0
700
1000
320
10000
340
ORIGINAL LOGICAL VOLUME #1
POSITION FROM THE HEAD OF STORAGE AREA OF LOGICAL VOLUME
0
310
UPDATE INFORMATION AREA
1500
1800
330
WRITE DATA AREA
2700
350
JOURNAL LOGICAL VOLUME #4

FIG.4

LOGICAL VOLUME NUMBER	VOLUME STATE	FORMAT	CAPACITY	PAIR NUMBER	PHYSICAL ADDRESS	
					STORAGE DEVICE NUMBER	POSITION FROM THE HEAD
1	ORIGINAL	OPEN3	3	1	1	0
2	ORIGINAL	OPEN6	6	2	1	3
3	BLANK	OPEN6	6	0	1	9
4	NORMAL	OPEN9	9	0	2	0
5	NORMAL	OPEN3	3	0	2	9
6	BLANK	OPEN6	6	0	2	12

400 VOLUME INFORMATION

FIG.5

PAIR NUMBER	PAIR STATE	ORIGINAL STORAGE SYSTEM NUMBER	ORIGINAL LOGICAL VOLUME NUMBER	SECOND STORAGE SYSTEM NUMBER	SECOND LOGICAL VOLUME NUMBER	GROUP NUMBER	COPY COMPLETE ADDRESS
1	NORMAL	1	1	2	1	1	0
2	NORMAL	1	2	2	3	1	0
3	BLANK	0	0	0	0	0	0
4	BLANK	0	0	0	0	0	0
5	BLANK	0	0	0	0	0	0

500 PAIR INFORMATION

FIG.6

GROUP NUMBER	GROUP STATE	PAIR SET	JOURNAL LOGICAL VOLUME NUMBER	UPDATE NUMBER
1	NORMAL	1,2	4	1
2	BLANK	0	0	0

600 GROUP INFORMATION

Steve Y. Cho, Reg. No. 44,612, (650) 326-2400
Titled: Storage System
Inventor(s): Yusuke Hirakawa, et al.
Filed: August 27, 2003 Dckt. No. 16869P-090100US
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FIG.7

	LOGICAL ADDRESS	
	LOGICAL VOLUME NUMBER	POSITION FROM THE HEAD OF STORAGE AREA OF LOGICAL VOLUME
UPDATE INFORMATION AREA HEAD ADDRESS	4	0
WRITE DATA AREA HEAD ADDRESS	4	700
UPDATE INFORMATION NEWEST ADDRESS	4	500
UPDATE INFORMATION OLDEST ADDRESS	4	200
WRITE DATA NEWEST ADDRESS	4	2200
WRITE DATA OLDEST ADDRESS	4	1300
READ INITIATION ADDRESS	4	400
RETRY INITIATION ADDRESS	4	300

700 POINTER INFORMATION

FIG.8

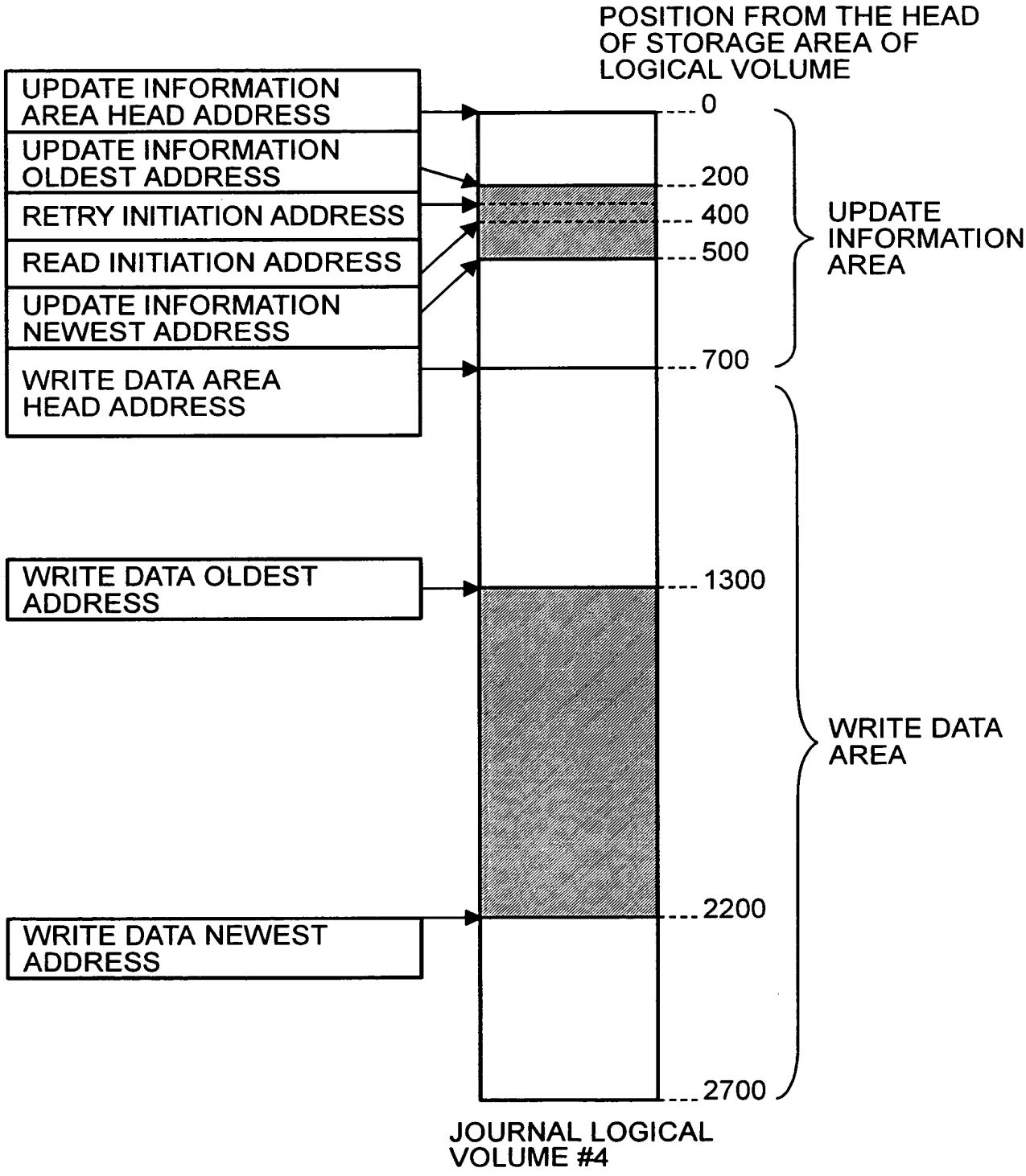

POSITION FROM THE HEAD OF STORAGE AREA OF LOGICAL VOLUME
UPDATE INFORMATION AREA HEAD ADDRESS
UPDATE INFORMATION OLDEST ADDRESS
RETRY INITIATION ADDRESS
READ INITIATION ADDRESS
UPDATE INFORMATION NEWEST ADDRESS
WRITE DATA AREA HEAD ADDRESS
WRITE DATA OLDEST ADDRESS
WRITE DATA NEWEST ADDRESS
0
200
400
500
700
1300
2200
2700
UPDATE INFORMATION AREA
WRITE DATA AREA
JOURNAL LOGICAL VOLUME #4

FIG.9

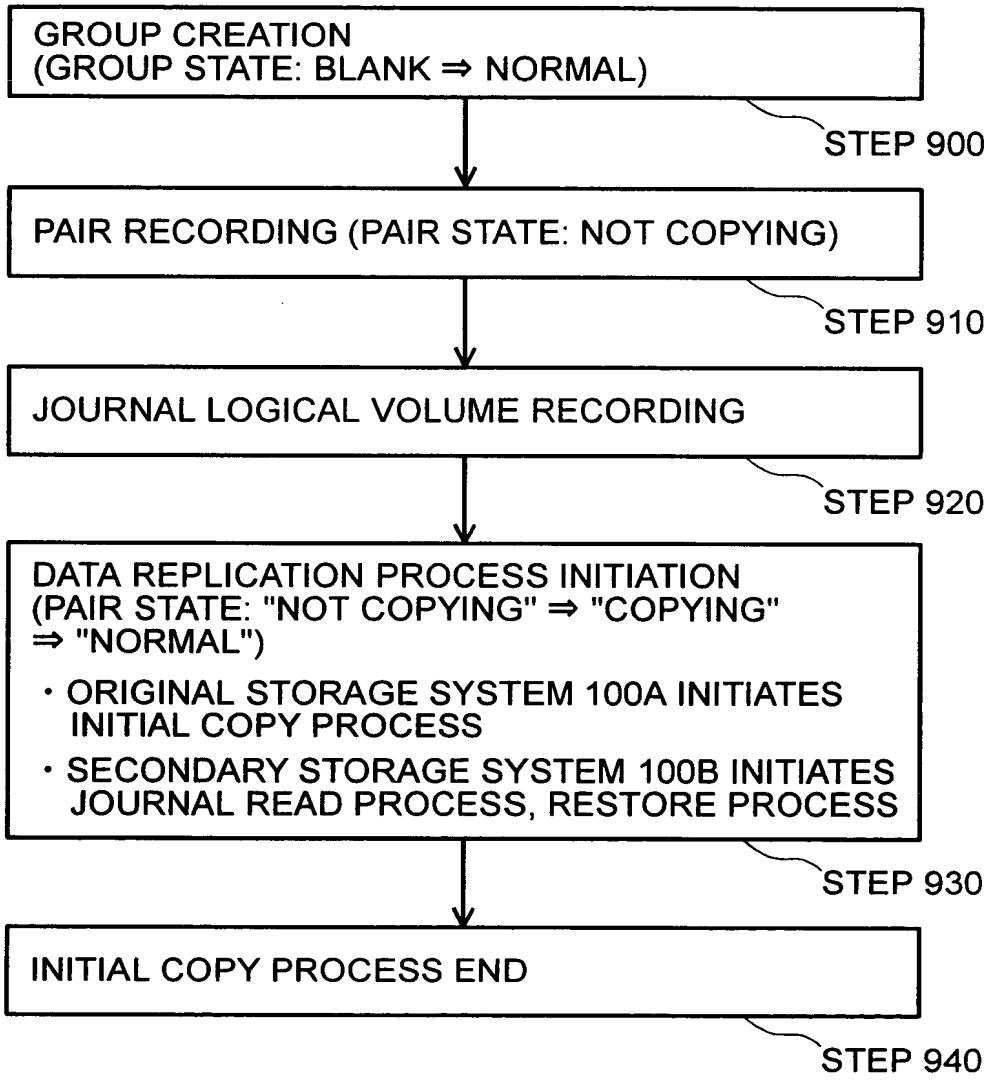

GROUP CREATION
(GROUP STATE: BLANK ⇒ NORMAL)
STEP 900
PAIR RECORDING (PAIR STATE: NOT COPYING)
STEP 910
JOURNAL LOGICAL VOLUME RECORDING
STEP 920
DATA REPLICATION PROCESS INITIATION
(PAIR STATE: "NOT COPYING" ⇒ "COPYING"
⇒ "NORMAL")
• ORIGINAL STORAGE SYSTEM 100A INITIATES INITIAL COPY PROCESS
• SECONDARY STORAGE SYSTEM 100B INITIATES JOURNAL READ PROCESS, RESTORE PROCESS
STEP 930
INITIAL COPY PROCESS END
STEP 940

FIG.10

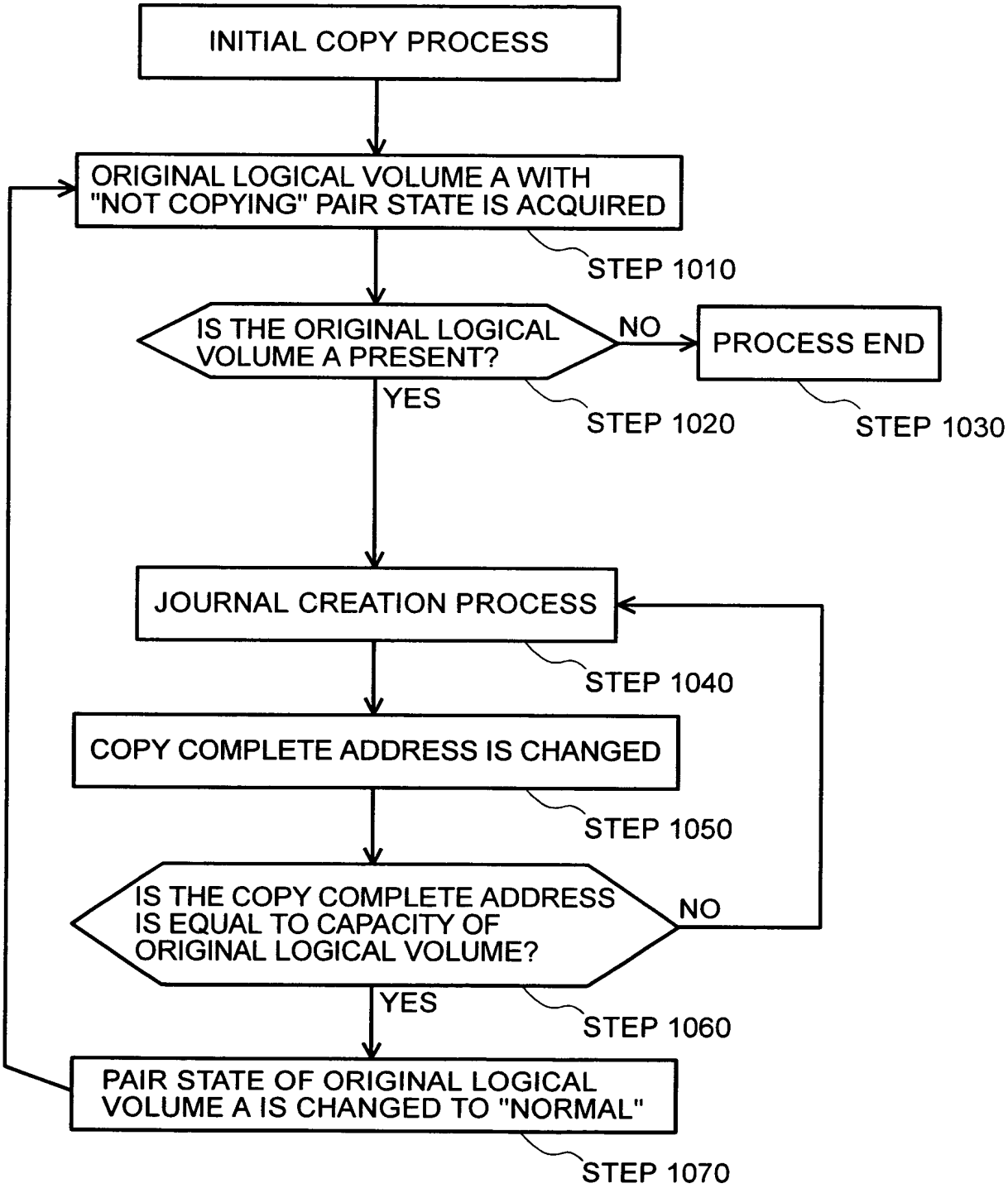

INITIAL COPY PROCESS
ORIGINAL LOGICAL VOLUME A WITH "NOT COPYING" PAIR STATE IS ACQUIRED
STEP 1010
IS THE ORIGINAL LOGICAL VOLUME A PRESENT?
NO
PROCESS END
YES
STEP 1020
STEP 1030
JOURNAL CREATION PROCESS
STEP 1040
COPY COMPLETE ADDRESS IS CHANGED
STEP 1050
IS THE COPY COMPLETE ADDRESS IS EQUAL TO CAPACITY OF ORIGINAL LOGICAL VOLUME?
NO
YES
STEP 1060
PAIR STATE OF ORIGINAL LOGICAL VOLUME A IS CHANGED TO "NORMAL"
STEP 1070

FIG.11

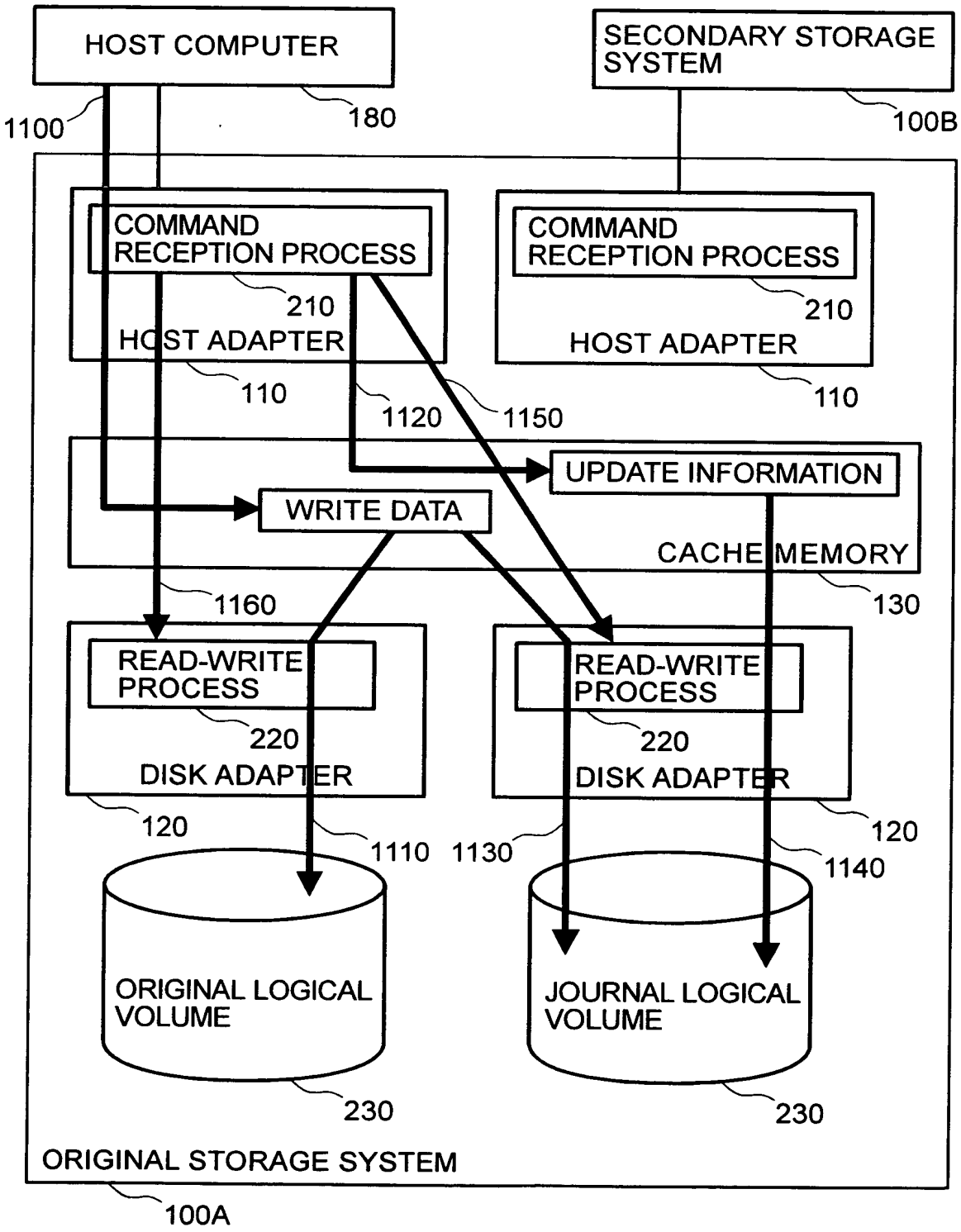

HOST COMPUTER
SECONDARY STORAGE SYSTEM
1100
180
100B
COMMAND RECEPTION PROCESS
210
HOST ADAPTER
110
COMMAND RECEPTION PROCESS
210
HOST ADAPTER
110
1120
1150
UPDATE INFORMATION
WRITE DATA
CACHE MEMORY
130
1160
READ-WRITE PROCESS
220
DISK ADAPTER
120
READ-WRITE PROCESS
220
DISK ADAPTER
120
1110
1130
1140
ORIGINAL LOGICAL VOLUME
JOURNAL LOGICAL VOLUME
230
230
ORIGINAL STORAGE SYSTEM
100A

FIG.12

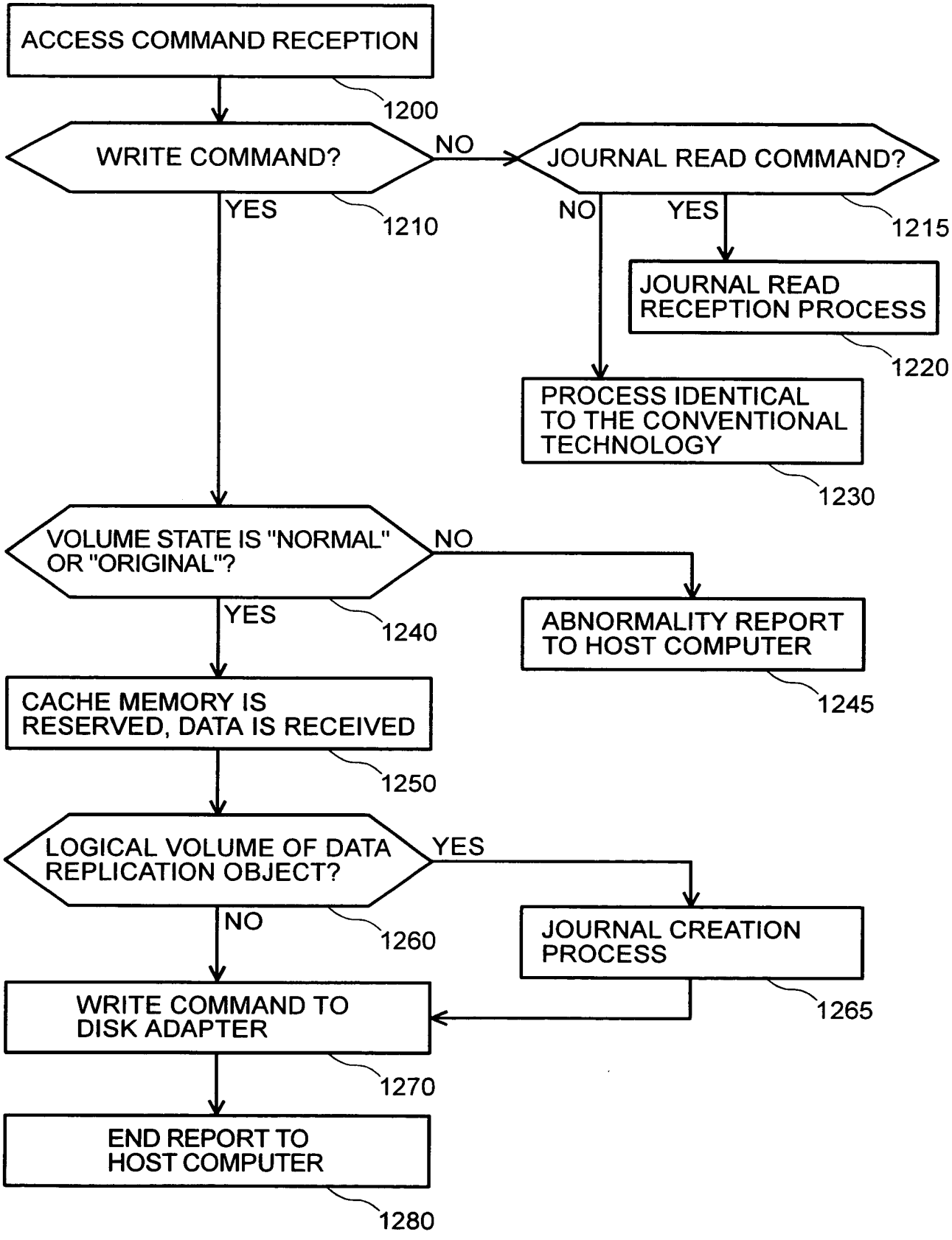

ACCESS COMMAND RECEPTION
1200
WRITE COMMAND?
NO
JOURNAL READ COMMAND?
YES
1210
NO
YES
1215
JOURNAL READ RECEPTION PROCESS
1220
PROCESS IDENTICAL TO THE CONVENTIONAL TECHNOLOGY
1230
VOLUME STATE IS "NORMAL" OR "ORIGINAL"?
NO
YES
1240
ABNORMALITY REPORT TO HOST COMPUTER
1245
CACHE MEMORY IS RESERVED, DATA IS RECEIVED
1250
LOGICAL VOLUME OF DATA REPLICATION OBJECT?
YES
NO
1260
JOURNAL CREATION PROCESS
1265
WRITE COMMAND TO DISK ADAPTER
1270
END REPORT TO HOST COMPUTER
1280

FIG.13

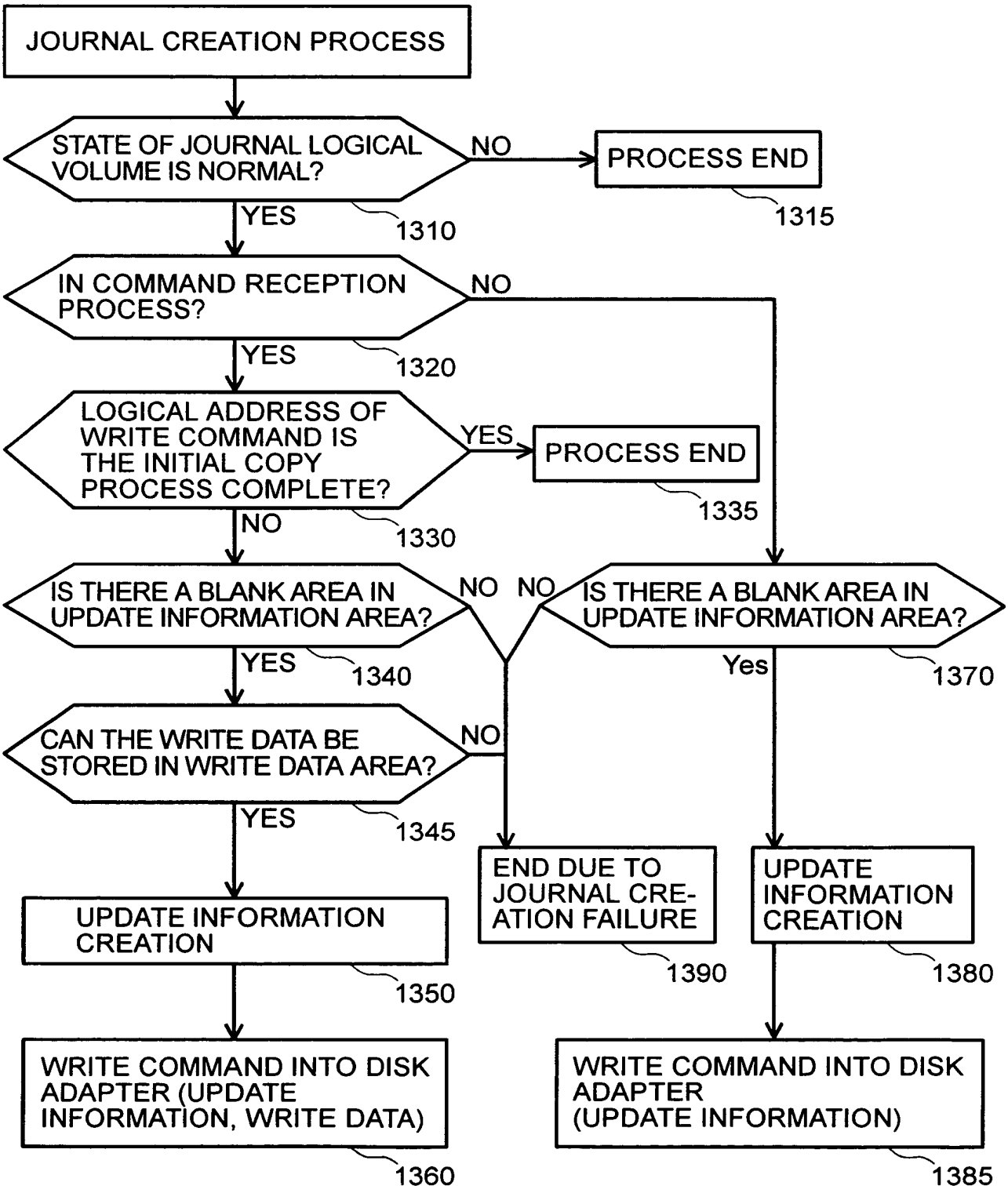

JOURNAL CREATION PROCESS
STATE OF JOURNAL LOGICAL VOLUME IS NORMAL?
NO
PROCESS END
1315
YES
1310
IN COMMAND RECEPTION PROCESS?
NO
YES
1320
LOGICAL ADDRESS OF WRITE COMMAND IS THE INITIAL COPY PROCESS COMPLETE?
YES
PROCESS END
1335
NO
1330
IS THERE A BLANK AREA IN UPDATE INFORMATION AREA?
NO
NO
IS THERE A BLANK AREA IN UPDATE INFORMATION AREA?
YES
1340
Yes
1370
CAN THE WRITE DATA BE STORED IN WRITE DATA AREA?
NO
YES
1345
END DUE TO JOURNAL CRE-ATION FAILURE
1390
UPDATE INFORMATION CREATION
1380
UPDATE INFORMATION CREATION
1350
WRITE COMMAND INTO DISK ADAPTER (UPDATE INFORMATION, WRITE DATA)
1360
WRITE COMMAND INTO DISK ADAPTER (UPDATE INFORMATION)
1385

FIG.14

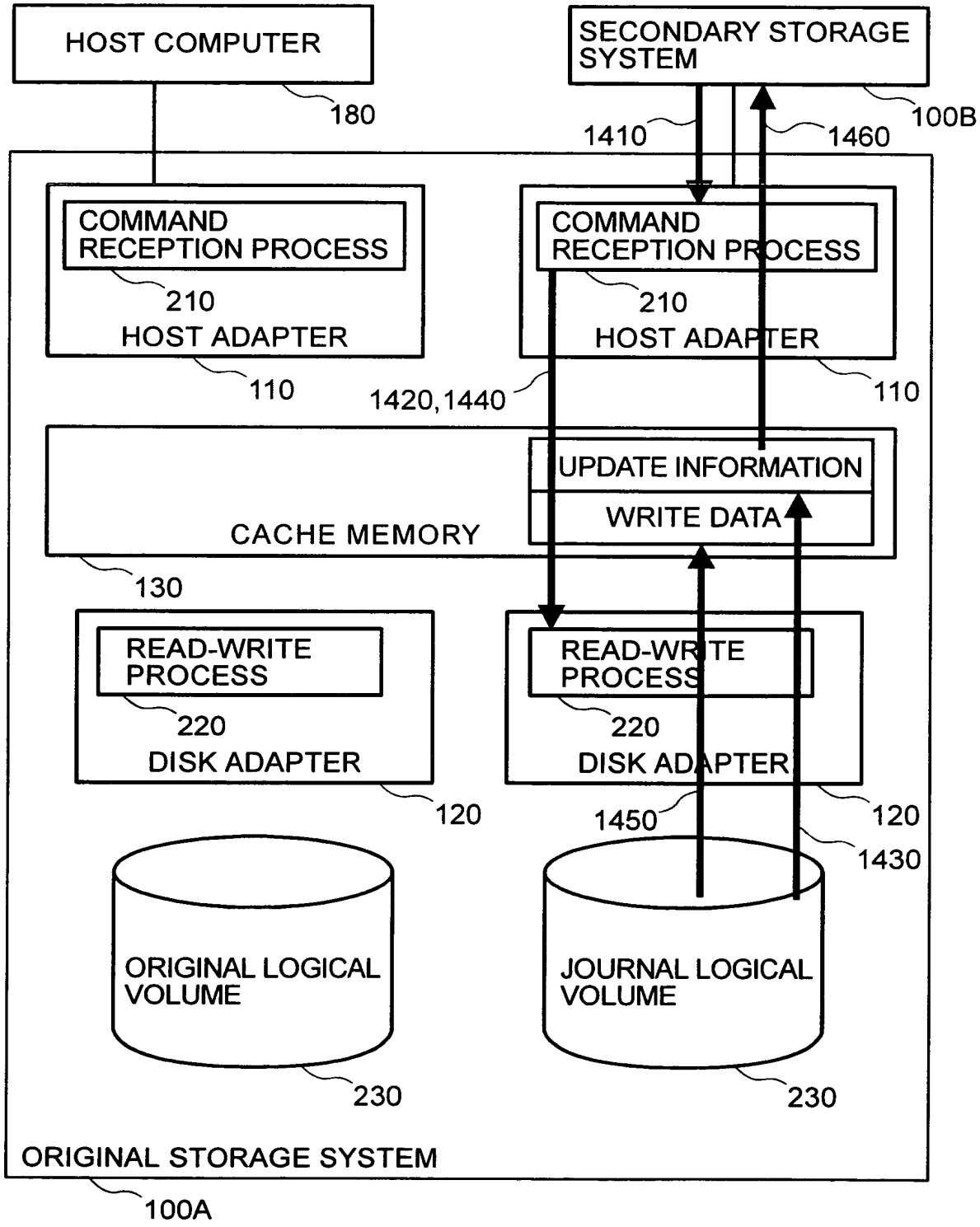

HOST COMPUTER
180
SECONDARY STORAGE SYSTEM
100B
1410
1460
COMMAND RECEPTION PROCESS
210
HOST ADAPTER
110
COMMAND RECEPTION PROCESS
210
HOST ADAPTER
110
1420,1440
UPDATE INFORMATION
WRITE DATA
CACHE MEMORY
130
READ-WRITE PROCESS
220
DISK ADAPTER
120
READ-WRITE PROCESS
220
DISK ADAPTER
120
1450
1430
ORIGINAL LOGICAL VOLUME
230
JOURNAL LOGICAL VOLUME
230
ORIGINAL STORAGE SYSTEM
100A

FIG.15

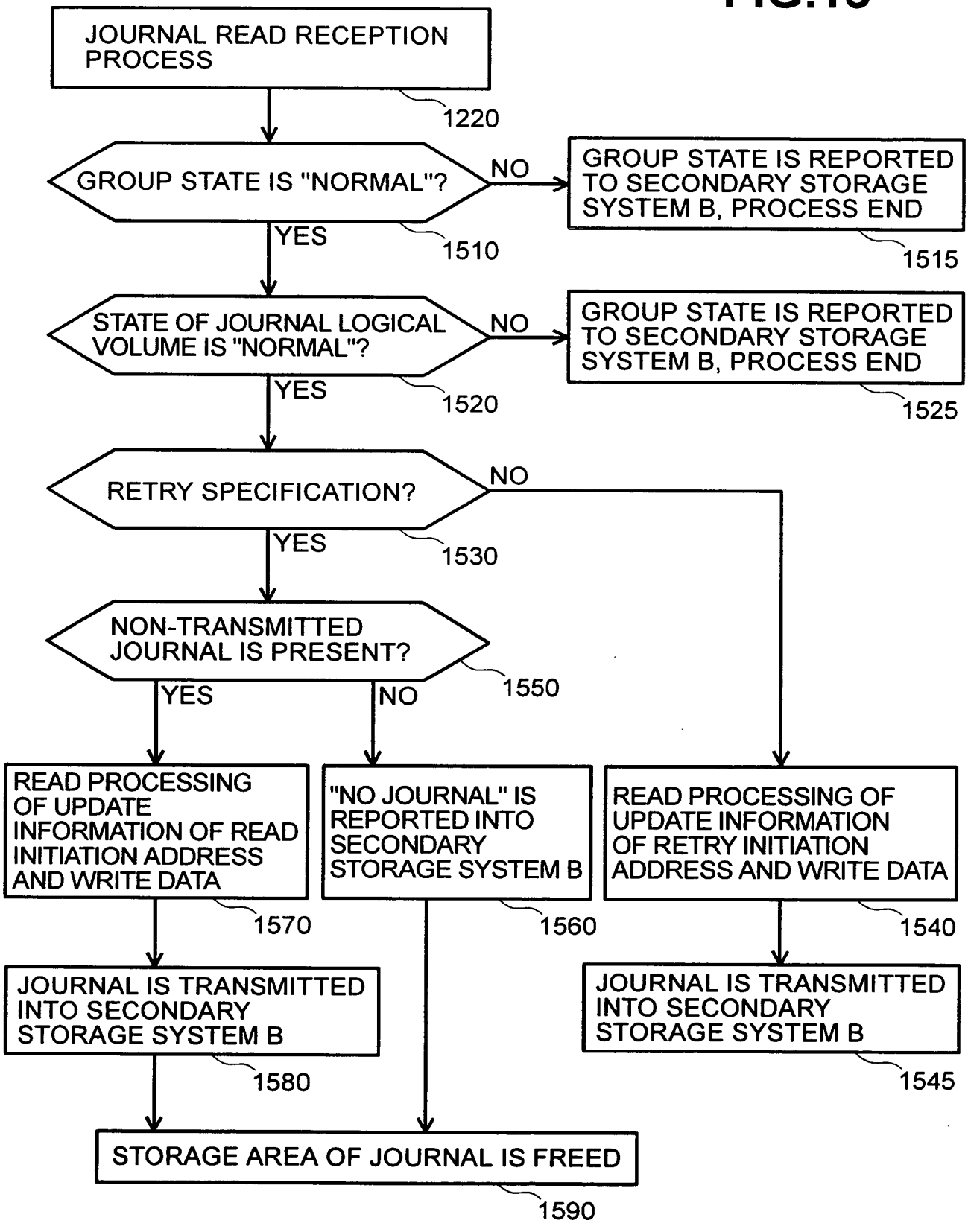

JOURNAL READ RECEPTION PROCESS
1220
GROUP STATE IS "NORMAL"?
NO
GROUP STATE IS REPORTED TO SECONDARY STORAGE SYSTEM B, PROCESS END
1515
YES
1510
STATE OF JOURNAL LOGICAL VOLUME IS "NORMAL"?
NO
GROUP STATE IS REPORTED TO SECONDARY STORAGE SYSTEM B, PROCESS END
1525
YES
1520
RETRY SPECIFICATION?
NO
YES
1530
NON-TRANSMITTED JOURNAL IS PRESENT?
1550
YES
NO
READ PROCESSING OF UPDATE INFORMATION OF READ INITIATION ADDRESS AND WRITE DATA
1570
"NO JOURNAL" IS REPORTED INTO SECONDARY STORAGE SYSTEM B
1560
READ PROCESSING OF UPDATE INFORMATION OF RETRY INITIATION ADDRESS AND WRITE DATA
1540
JOURNAL IS TRANSMITTED INTO SECONDARY STORAGE SYSTEM B
1580
JOURNAL IS TRANSMITTED INTO SECONDARY STORAGE SYSTEM B
1545
STORAGE AREA OF JOURNAL IS FREED
1590

FIG.16

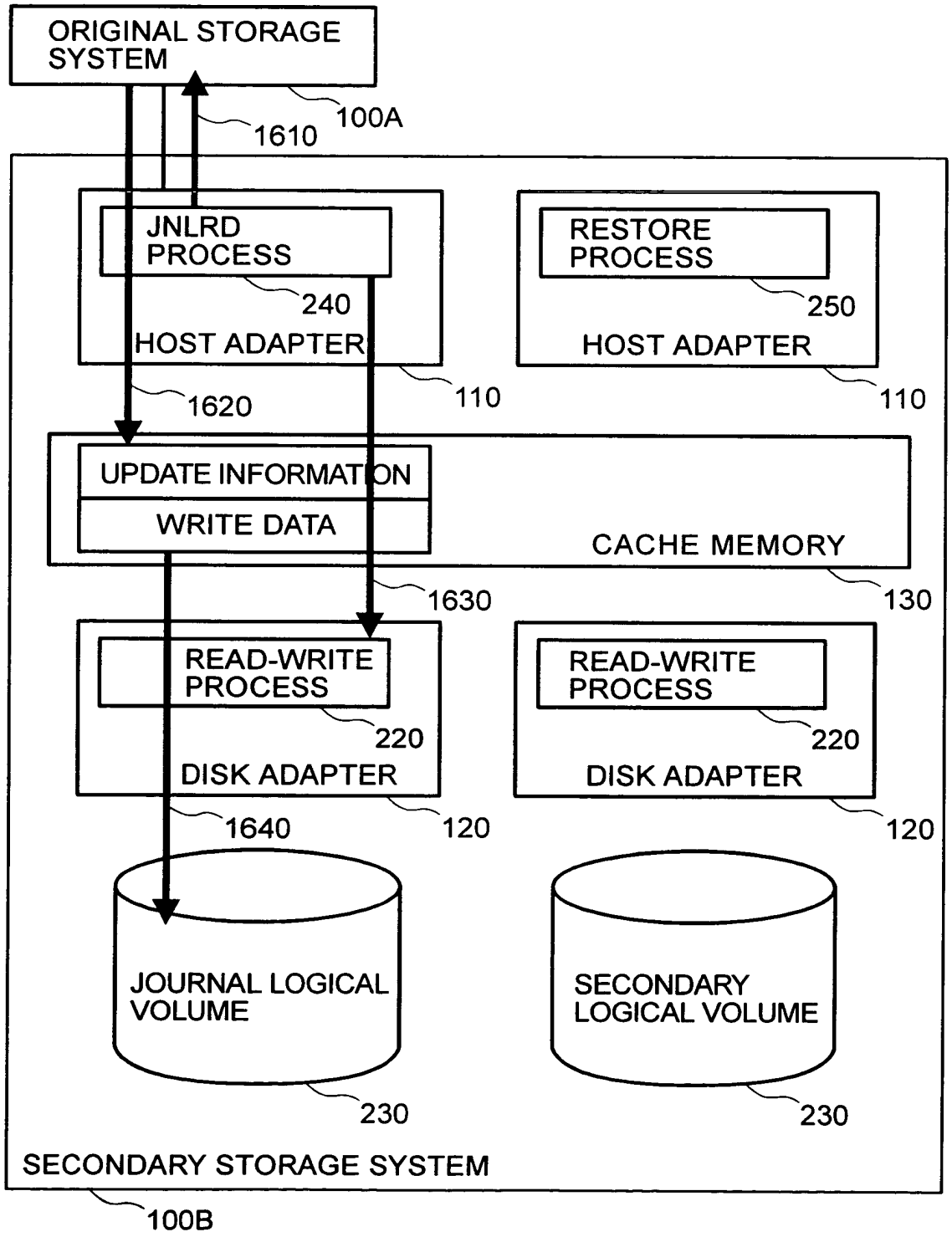

ORIGINAL STORAGE SYSTEM
100A
1610
JNLRD PROCESS
240
HOST ADAPTER
110
RESTORE PROCESS
250
HOST ADAPTER
110
1620
UPDATE INFORMATION
WRITE DATA
CACHE MEMORY
130
1630
READ-WRITE PROCESS
220
DISK ADAPTER
120
READ-WRITE PROCESS
220
DISK ADAPTER
120
1640
JOURNAL LOGICAL VOLUME
230
SECONDARY LOGICAL VOLUME
230
SECONDARY STORAGE SYSTEM
100B

FIG.17

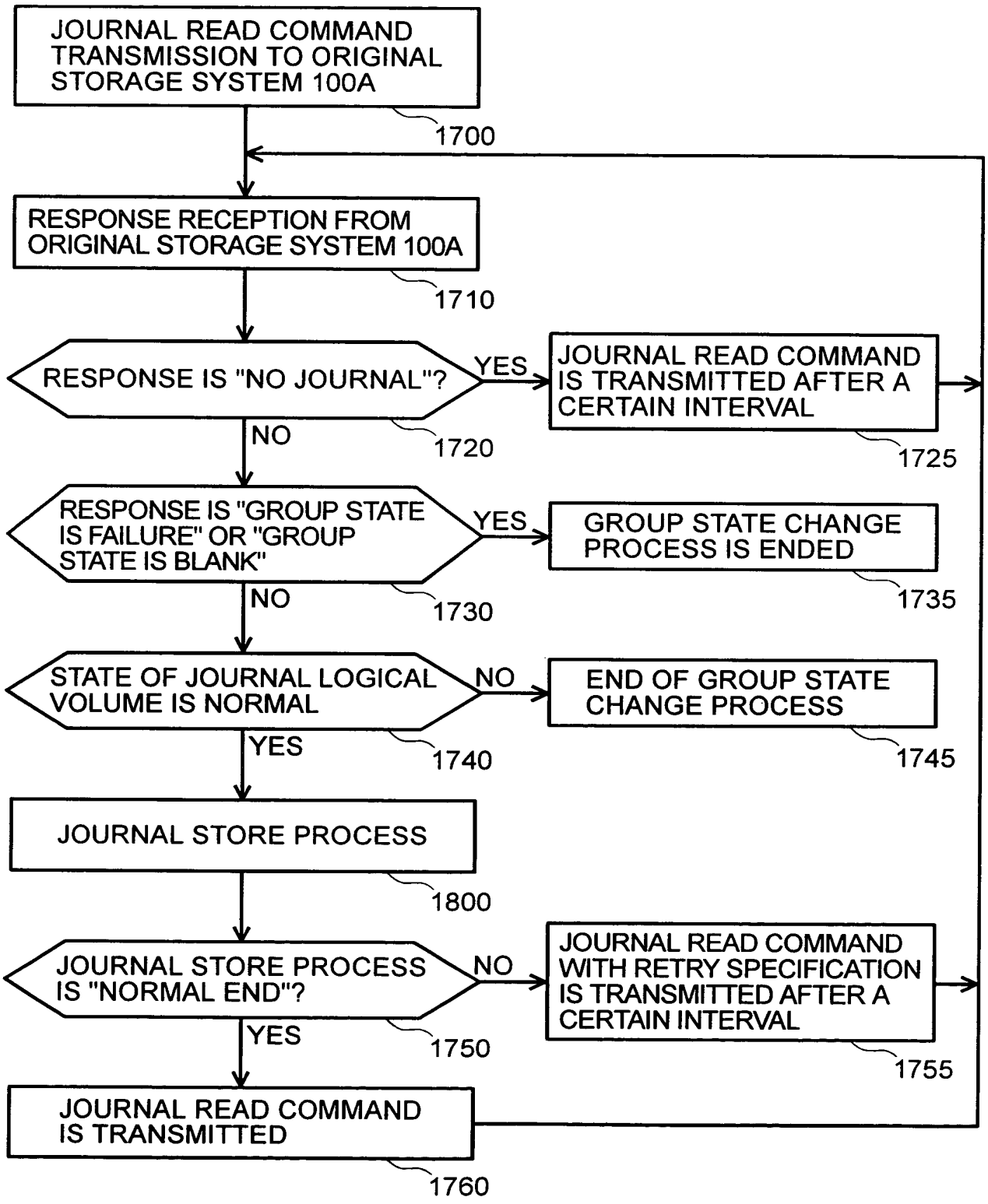

JOURNAL READ COMMAND TRANSMISSION TO ORIGINAL STORAGE SYSTEM 100A
1700
RESPONSE RECEPTION FROM ORIGINAL STORAGE SYSTEM 100A
1710
RESPONSE IS "NO JOURNAL"?
YES
JOURNAL READ COMMAND IS TRANSMITTED AFTER A CERTAIN INTERVAL
1725
NO
1720
RESPONSE IS "GROUP STATE IS FAILURE" OR "GROUP STATE IS BLANK"
YES
GROUP STATE CHANGE PROCESS IS ENDED
1735
NO
1730
STATE OF JOURNAL LOGICAL VOLUME IS NORMAL
NO
END OF GROUP STATE CHANGE PROCESS
1745
YES
1740
JOURNAL STORE PROCESS
1800
JOURNAL STORE PROCESS IS "NORMAL END"?
NO
JOURNAL READ COMMAND WITH RETRY SPECIFICATION IS TRANSMITTED AFTER A CERTAIN INTERVAL
1755
YES
1750
JOURNAL READ COMMAND IS TRANSMITTED
1760

FIG.18

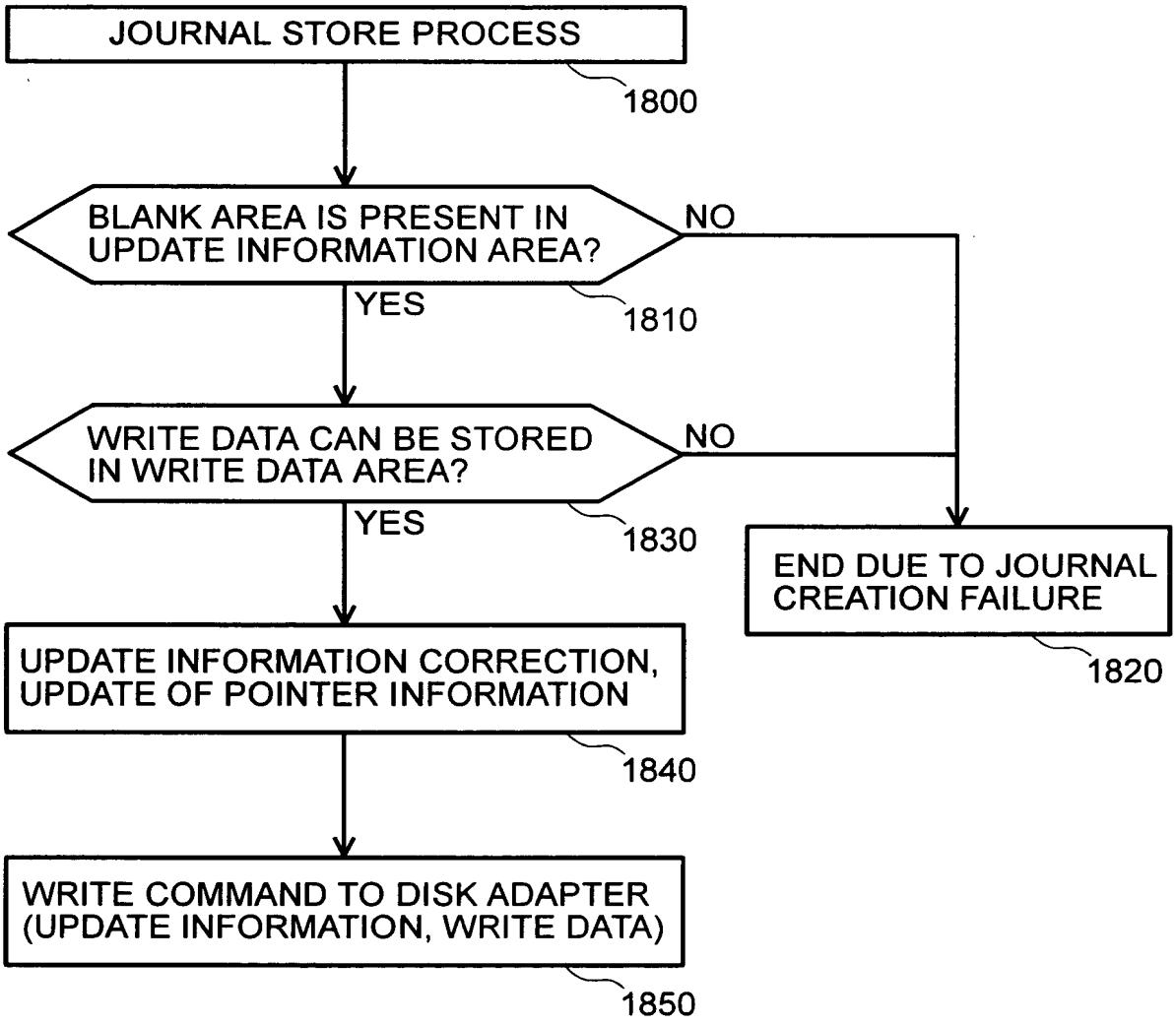

JOURNAL STORE PROCESS
1800
BLANK AREA IS PRESENT IN UPDATE INFORMATION AREA?
NO
YES
1810
WRITE DATA CAN BE STORED IN WRITE DATA AREA?
NO
YES
1830
END DUE TO JOURNAL CREATION FAILURE
1820
UPDATE INFORMATION CORRECTION, UPDATE OF POINTER INFORMATION
1840
WRITE COMMAND TO DISK ADAPTER (UPDATE INFORMATION, WRITE DATA)
1850

FIG.19

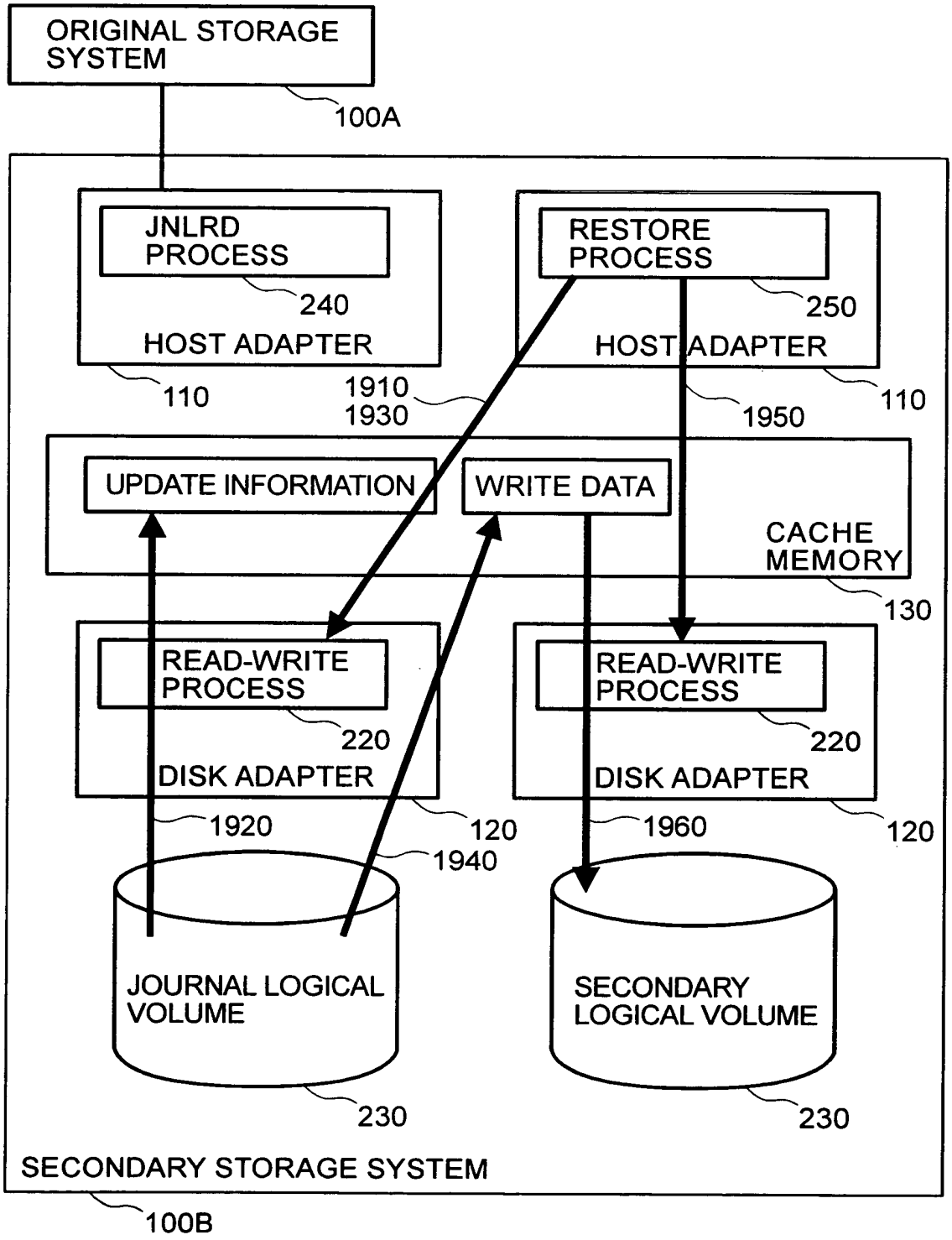

ORIGINAL STORAGE SYSTEM
100A
JNLRD PROCESS
240
HOST ADAPTER
110
RESTORE PROCESS
250
HOST ADAPTER
110
1910
1930
1950
UPDATE INFORMATION
WRITE DATA
CACHE MEMORY
130
READ-WRITE PROCESS
220
DISK ADAPTER
120
READ-WRITE PROCESS
220
DISK ADAPTER
120
1920
1940
1960
JOURNAL LOGICAL VOLUME
230
SECONDARY LOGICAL VOLUME
230
SECONDARY STORAGE SYSTEM
100B

FIG.20

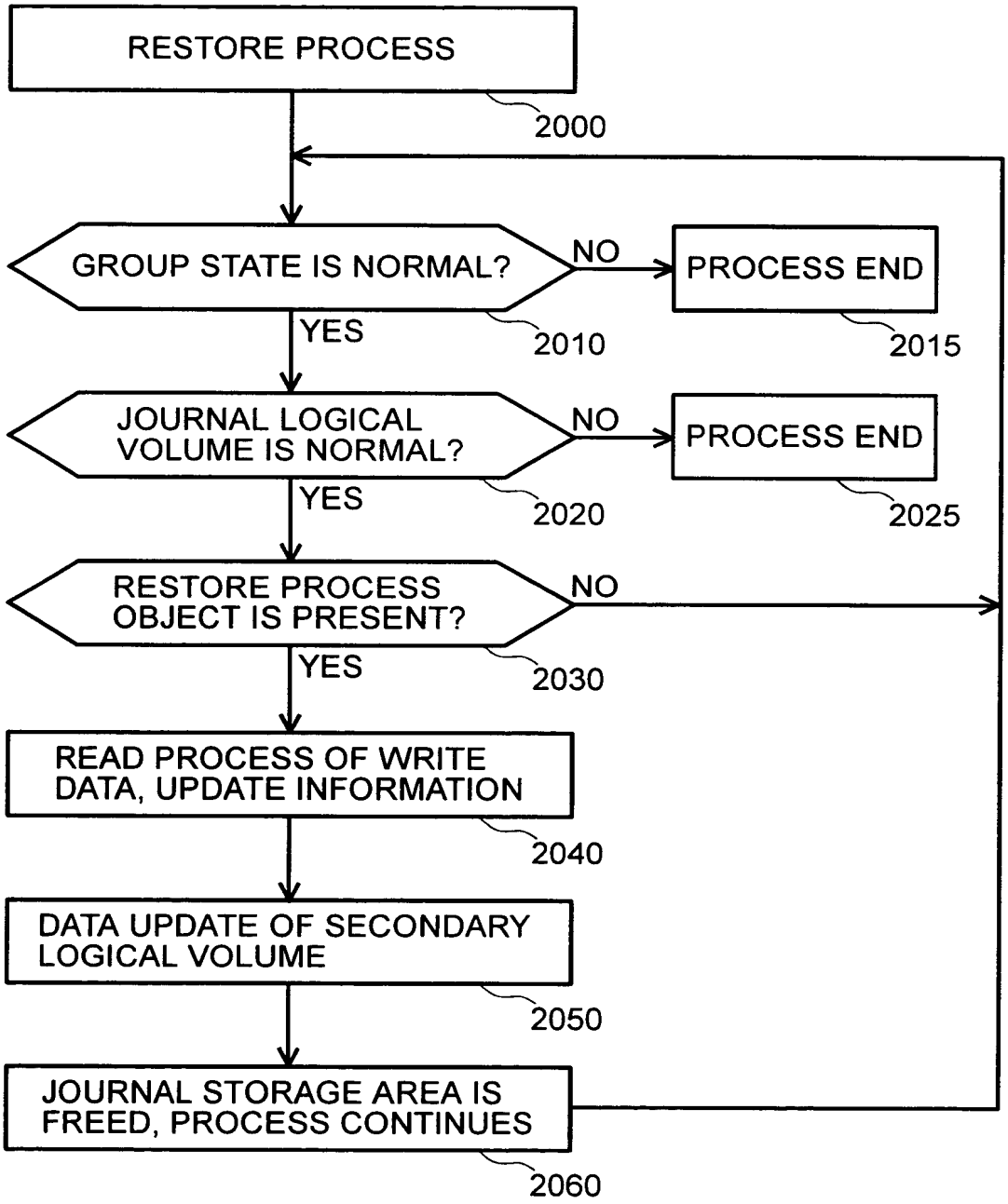

RESTORE PROCESS
2000
GROUP STATE IS NORMAL?
NO
PROCESS END
2010
2015
YES
JOURNAL LOGICAL VOLUME IS NORMAL?
NO
PROCESS END
2020
2025
YES
RESTORE PROCESS OBJECT IS PRESENT?
NO
2030
YES
READ PROCESS OF WRITE DATA, UPDATE INFORMATION
2040
DATA UPDATE OF SECONDARY LOGICAL VOLUME
2050
JOURNAL STORAGE AREA IS FREED, PROCESS CONTINUES
2060

FIG.21

SETTING ITEM	EXAMPLE OF SET VALUE
INSTANT OF TIME AT WHICH WRITE COMMAND WAS RECEIVED	3/17/1999, 22:20:10
GROUP NUMBER	1
UPDATE NUMBER	4
LOGICAL ADDRESS OF WRITE COMMAND	LOGICAL VOLUME NUMBER: 1 POSITION FROM HEAD OF STORAGE AREA OF LOGICAL VOLUME: 700
DATA SIZE OF WRITE DATA	300
LOGICAL ADDRESS OF JOURNAL LOGICAL VOLUME STORING THE WRITE DATA	LOGICAL VOLUME NUMBER: 4 POSITION FROM HEAD OF STORAGE AREA OF LOGICAL VOLUME: 1500

310 UPDATE INFORMATION

FIG.22

SETTING ITEM	EXAMPLE OF SET VALUE
INSTANT OF TIME AT WHICH WRITE COMMAND WAS RECEIVED	3/17/1999, 22:20:10
GROUP NUMBER	1
UPDATE NUMBER	4
LOGICAL ADDRESS OF WRITE COMMAND	LOGICAL VOLUME NUMBER: 1 POSITION FROM HEAD OF STORAGE AREA OF LOGICAL VOLUME: 800
DATA SIZE OF WRITE DATA	100
LOGICAL ADDRESS OF JOURNAL LOGICAL VOLUME STORING THE WRITE DATA	LOGICAL VOLUME NUMBER: 4 POSITION FROM HEAD OF STORAGE AREA OF LOGICAL VOLUME: 2200

FIG.23

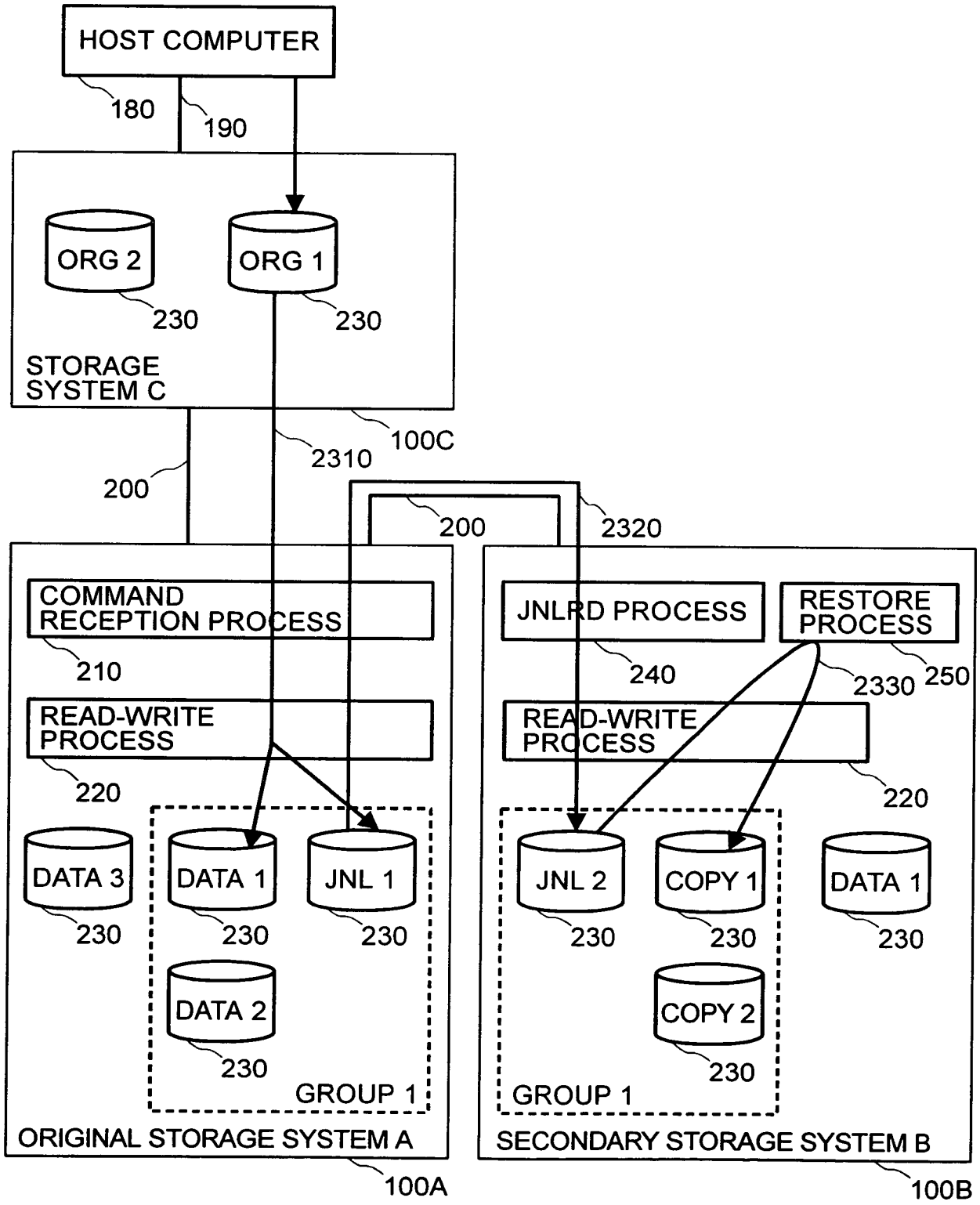
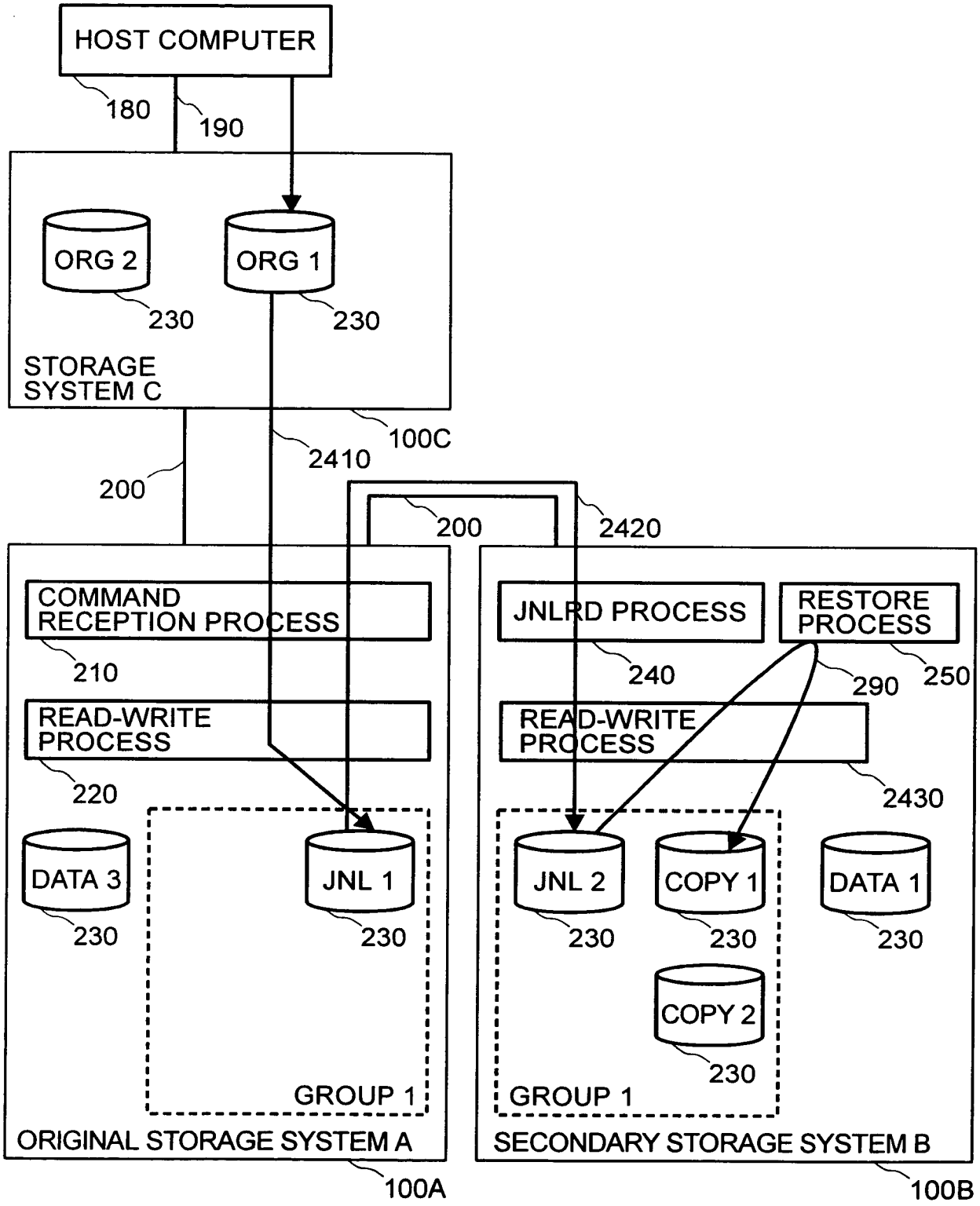

HOST COMPUTER
180
190
ORG 2
ORG 1
230
230
STORAGE SYSTEM C
100C
2310
200
200
2320
COMMAND RECEPTION PROCESS
210
READ-WRITE PROCESS
220
JNLRD PROCESS
240
RESTORE PROCESS
250
2330
READ-WRITE PROCESS
220
DATA 3
DATA 1
JNL 1
DATA 2
230
230
230
230
JNL 2
COPY 1
DATA 1
COPY 2
230
230
230
230
GROUP 1
GROUP 1
ORIGINAL STORAGE SYSTEM A
SECONDARY STORAGE SYSTEM B
100A
100B

FIG.24


HOST COMPUTER
180
190
ORG 2
ORG 1
230
230
STORAGE SYSTEM C
100C
2410
200
200
2420
COMMAND RECEPTION PROCESS
210
READ-WRITE PROCESS
220
DATA 3
230
JNL 1
230
GROUP 1
ORIGINAL STORAGE SYSTEM A
100A
JNLRD PROCESS
240
RESTORE PROCESS
250
290
READ-WRITE PROCESS
2430
JNL 2
230
COPY 1
230
DATA 1
230
COPY 2
230
GROUP 1
SECONDARY STORAGE SYSTEM B
100B